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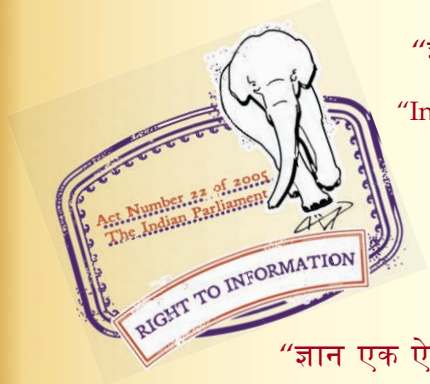
IS 11891 (1986): Lubrication and Oil Seal System for Dynamic Compressors [MED 22: Compressor, Blowers and Exhausters]

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"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

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UDC 621·15 - 722 ( First Reprint OCTOBER1998 ) IS ; 11891 - 1986
( Reaffirmed 2001 )

*Indian Standard*

# SPECIFICATION FOR LUBRICATION AND OIL SEAL SYSTEM FOR DYNAMIC COMPRESSORS

[ Ref : Doc : EDC 62 ( 4523 ) ] Compressors Sectional Committee, EDC 62; Dynamic Compressors Subcommittee, EDC 62 : 4

**1. Scope** — Lays down the minimum requirements for the centralised recirculatory lubricating and sealing oil systems for high speed and high pressure centrifugal compressor installations in petro-chemical, fertiliser, refineries, etc, with various prime-movers steam turbine, gas turbine, electric motor, with or without gear boxes.

**2. Terminology** — For the purpose of this standard the following definitions shall apply.

**2.1** *Equipment* — The main machinery in the compressor train for which oil systems are required.

**2.2** *Special Application* — A system which has been designed and constructed for at least three years of continuous supply of oil as specified to the equipment.

**2.3** *Block-in-Time* — The period required to depressurize or isolate the compressor or another item of equipment, its system after tripping the prime-mover.

**2.4** *Coast-Down-Time* — The time period required by the equipments from trip to stop.

**2.5** *Cool-off Time* — The period for which the oil circulation is to be maintained to minimize damage due to the heat effects to the equipment.

**2.6** *Control Oil* — The oil required to actuate components like relays, pistons, etc, of the main equipment.

**2.7** *Console* — The complete oil system under reference with all its accessories or more packages arranged in such a way that site connections are minimum.

**2.8** *Component* — The items which constitute the oil system, as for example, pumps, motors, couplings, coolers, etc.

**2.9** *Main Pump* — The pump with continuous operation.

**2.10** *Shaft Driven* — The oil pump which is driven by the shaft of one of the main equipment.

**2.11** *Emergency Pump* — The oil pump which shall facilitate cooling of the steam turbine prime-mover, the main equipment after coast-down time for safe rest of the equipment in the event of main and standby pumps failure.

**2.12** *Standby Pump* — The pump which meets the system requirements when the main pump fails.

**2.13** *Booster Pump* — Pumps located at downstream of another pump for increasing the pressure of the latter.

**2.14** *Transflow Valve* — A valve which maintains the system continuity during changeover and at the same time provide tight shut-off of the idle component for maintenance.

**2.15** *Normally Open and Normally Closed* — Designate the position of the automatically controlled electric switches, valves, etc, in a degenerised conditions.

**2.16** *Centralised Lubrication System* — A system in which two or more lubrication points on a machine or group of machines are served with the same lubricant from a common source.

**2.17** *Total Equivalent Length of Pipe* — The total lengths of straight pipe plus the total of the pipe length equivalent of associated fittings in the relevant part of the system. This term is used in the calculation of pressure drop.

**2.18** *Pressure Drop* — The difference in pressure of a medium before and after an event, that is, the medium having followed through a length of pipe.

Adopted 12 September 1986  Gr 6

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

**2.19** *Laminar Flow* — A type of flow in which, there is a continuous steady motion of the particles, the motion at a fixed point varying no definite manner.

**2.20** *Turbulent Flow* — A type of fluid flow in which there is unsteady motion of the particles, the motion at a fixed point varying in no definite manner.

**2.21** *Rheological Properties* — Properties relating to rheology, the science of the deformation and flow of matter.

**2.22** *Strainer* — A device for removing coarse and impure particles from a lubricant.

**2.23** *Filter* — A device for fine filteration of a lubricant in order to obtain the required degree of cleanliness in the system.

**2.24** *Classification of Oil Lubrication System*

**2.24.1** *Circulating oil system* — System in which lubricant medium after use is collected and returned to the reservoir.

**2.24.1.1** Circulating oil system is a continuous type of system and can be either volumetric or proportionate. The volumetric systems are applicable to only small capacity systems.

**2.24.2** *Total loss oil system* — System in which the lubricant once fed to lubrication point is not returned to the system.

**2.24.2.1** Total loss oil systems may be sub-classified into intermittent and continuous type of systems. Intermittent type of system may be either volumetric or proportionate while continuous type of system may be proportionate only.

## 3. Design Criteria

**3.1** *General*

**3.1.1** The system shall be designed to meet all the normal operating conditions for the safe operation of the equipment.

**3.1.2** The system shall be guaranteed for minimum of two years of uninterrupted operation.

**3.1.3** When the equipment is supplied by others then the oil system operating parameters shall be mutually agreed by the supplier and the purchaser.

**3.1.4** The system shall be designed for unsheltered and outdoor operation but it shall also be suitable for the specified site conditions.

**3.1.5** The supplier and purchaser shall mutually agree upon the arrangement and layout of the system components preferably in two or more packages.

**3.1.5.1** Each package shall be mounted on a flat or fabricated steel base of drip-rim type design with 19 mm minimum drain connection. The fabricated structural shall be provided with suitably located vent and grant holes and these shall be provided with 12·5 mm high steel curbing for preventing seepage of accumulated water or oil.

**3.1.6** The pipe-routing shall be such that operation and maintenance of the system components may be done with minimum difficulty.

**3.1.7** Necessary connections shall be provided for draining, cleaning and refilling the standby components of the system when the main components are in operation.

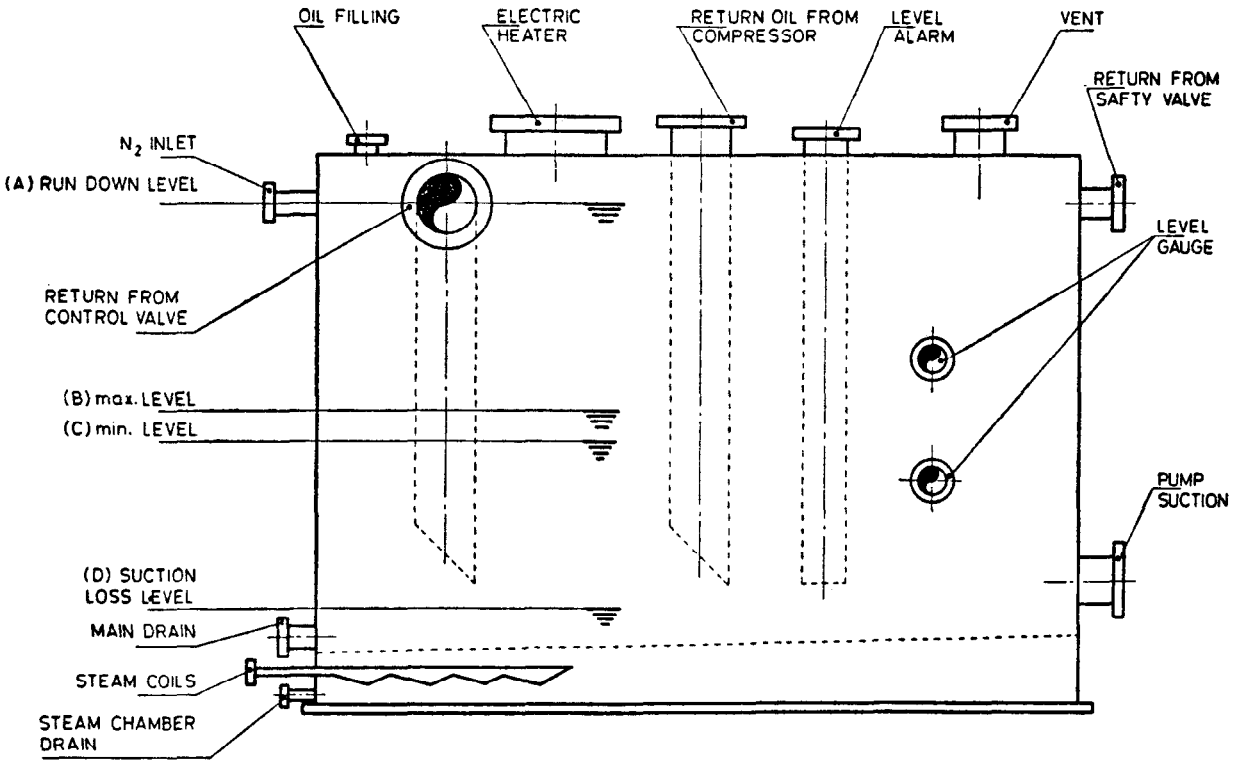
**3.1.8** The general requirements of the system with regard to manufacture noise level and special system requirements like electrical hazard class, etc, which may necessitate addition of some specialised equipment shall be mutually agreed to by the purchaser and the supplier.

**3.1.9** Pressure vessels like filters and accumulators, etc, shall be designed and manufactured as per IS : 2825-1969 'Code for unfired pressure vessels'. The coolers shall be designed and manufactured as per IS : 2825-1969 and IS : 4503-1967 'Shell and tube type heat exchangers .

**3.1.10** A single hydro-carbon oil shall be used in the system preferably of 40 to 60 cst at 40°C. For steam turbine driven installations the oil shall conform to IS : 1012-1978 'Turbine lubricating oils (*first revision*)'.

**3.1.11** All the welding details and welding practices shall be as per IS : 816-1969 'Code of practice for use of metal arc welding for general construction in mild steel (*first revision*)'.

**3.2** *Oil Reservoirs* (*Fig. 1*)




**Note 1** — Charge capacity is the total volume below level 'A'
**Note 2** — Low level alarm is set at level 'C'
**Note 3** — Normal operating range is any level between level 'B' and 'C'
**Note 4** — Retention capacity is the total volume below level 'C'
**Note 5** — Run-down capacity is the volume between levels 'A' and 'B'
**Note 6** — Working capacity is the volume between levels 'C' and 'D'

FIG. 1 LUBE OIL RESERVOIR

**3.2.1** The oil reservoirs shall not be integral with the equipment baseplate and shall be of rigid and vibration-free design. The sides shall be suitably reinforced with ribs. The sides shall be minimum of 6 mm thick.

**3.2.2** A minimum of two pairs of lifting lugs of sturdy design shall be provided for safe lifting and transportation.

**3.2.3** The bottom base of the oil reservoir shall be of a single thick plate or fabricated base with suitably spaced anchor foundation bolts.

**3.2.4** The top plate of the tank shall not contain any through holes. The openings, if provided shall be raised to a minimum of 100 mm. The top plate shall be designed to avoid any accumulation of water and dirt. In case of top-mounted components, suitably reinforcements shall be provided to prevent sagging.

**3.2.5** Manhole openings shall be provided for access to cleaning and inspection of all partitioned areas. These openings shall be covered easily with suitable removable type covers with handles. Handrails shall be provided for easy access to the bottom of the tank.

**3.2.6** A suitable filler-breather shall be provided on the top plate.

**3.2.7** A suitably sized and strategically positioned vent connection shall be provided on the top plate to eliminate over pressurising of the tank due to fume formation or due to leaking of the compressor seals via the oil drains.

**3.2.8** An over-pressure protective device shall be incorporated when specified in the enquiry.

**3.2.9** The top plate shall be suitably reinforced to take the weight of the top mounted degassification system wherever applicable, which orientation is to be mutually agreed to by the purchaser and the supplier.

**3.2.10** A partition plate with suitable flow openings shall be provided in the oil reservoir to minimise the turbulence of the return oil reaching the pump suction branches. The height of this partition plate shall be to the maximum operating level.

**3.2.11** The bottom of the reservoir shall be sloped to a low-point drain connection. The slope shall be a minimum of 1 degree for effective drainage of the sediments.

**3.2.12** All pump-suction connections shall be located on the high end of the reservoir bottom.

**3.2.13** All return-oil lines shall enter the reservoir above the run-down level. These shall also be away from the pump suction.

**3.2.14** All pipe connections shall be flanged.

**3.2.15** Flanged type oil level indicator shall be positioned to indicate oil level 25 mm above maximum operating level to a point 50 mm below operating level.

**3.3** *Criterion for Sizing of Reservoir*

**3.3.1** The retention shall be 8 minutes, considering normal flow and volume of oil contained below minimum operating level.

**3.3.2** The run-down capacity shall be determined by considering oil contained in system components such as bearing, seal housing, control elements, drain piping and overhead tank, etc, and which drains back to reservoir during plant shut down.

**3.3.3** The capacity between minimum and maximum operating levels shall be determined based on seal oil discharge rates and 3 days of operation without addition of oil. In case there shall be 100 mm difference in heights between minimum and maximum operating levels.

**3.3.4** The free surface of oil shall be designed to have a valve of 0·086 2 $m^2$/litre/minute of normal flow.

**3.3.5** To enable starting up of system in cold weather, either steam heater or thermostatically controlled electric heater shall be provided. The device shall be designed to heat up the charge capacity within 12 h from minimum site ambient temperature to equipment manufacturer recommended temperature. In case of electric heater watt density shall be 2·25 watts/$cm^2$.

**3.3.6** Suitable provision shall be made for access to the components mounted on the top of reservoir.

**3.4** *Pumps and Driving Equipment*

**3.4.1** The pumps shall be suitable for horizontal installation.

**3.4.2** The pump shall be of positive displacement type [*see* 4.1 of IS : 8593 ( Part 1 )-1977 'Recommendations for centralised lubrication as applied to plant and machinery: Part 1 Oil lubrication' ].

**3.4.3** The pumps shall be equipped with a suitable mechanical seal.

**3.4.4** Flexible coupling preferably spacer type, with suitable oil resistant rubber pads shall be used for the pumps assemblies. Removable, rigid and non-sparking coupling guards shall be provided to enclose all exposed couplings.

**3.4.5** Each pump shall have its individual prime mover and unless otherwise specified the main pump shall be steam turbine driven and the standby electric motor.

**3.4.6** When the steam turbine is auxiliary pump prime mover, the overspeed trip shall be set at a minimum of 25 percent above the normal operating speed.

**3.4.7** The motor prime mover for the pumps shall be increased safety, totally enclosed fan cooled with class B insulation. The design manufacture and testing shall conform to IS : 6381-1972 "Construction and testing of electrical apparatus with type of protection 'E'" and IS : 325-1978 'Three-phase induction motors ( *fourth revision* )'.

**3.4.8** Drivers for the pump shall be capable of operating at the pump relief-valve setting for the seal oil pumps and for lubricating oil pumps the pump relief-valve setting or 120 bars whichever is less with oil viscosity corresponding to a temperature of 40°C.

**3.4.9** The lubricating oil pump capacities shall cater to the system's maximum requirements inclusive of transient conditions plus a minimum of 15 percent of the above usage.

**3.4.10** Seal oil booster pumps shall be designed for maximum system requirements ( inclusive of normal wear ) plus 40 litres per minute or 20 percent of requirement whichever is higher. A low pressure switch in the suction line shall be provided to alarm or to trip these pumps.

**3.4.11** The prime movers either motor- or turbine-driven shall be sized considering the following criterion.

**3.4.11 1** *Motor driver* — These shall have a minimum nameplate rating corresponding to the percentage of the pump rated brake horse power as follows ( that is NXMF ).

| *Nominal Power Required by the Pumps ( N )* | *Multiplication Factor ( MF )* |
|---|---|
| 18 kW ( 25 HP ) and less | 1·25 |
| 22 kW ( 30 HP ) to 55 kW ( 75 HP ) | 1·15 |
| Above 55 kW ( 75 HP ) | 1·1 |

**3.4.11.2** *Turbine driver* — The turbine shaft brake horse power shall be 1·10 times the pump brake horse power based on minimum inlet enthalpy conditions and maximum exhaust steam pressure specified.

**3.4.12** A by-pass pressure control valve shall be incorporated in the system sized for full flow of both the pumps.

**3.4.13** All pumps shall be installed with flooded suction.

**3.4.14** A cone-type strainer with a flow area of 150 percent of the suction pipe cross sectional area, located between the pump suction flange and upstream isolation valve, shall be provided.

**3.4.15** The stainless steel mesh of pump suction strainer shall be of 800 to 1 000 $\mu$ or as specified by the pump manufacturer.

**3.4.16** A low pressure switch shall be provided to start the standby pump when the main pump is unable to meet the system requirements.

**3.4.16.1** A suitable piping arrangement shall be made across the low pressure switch for checking the healthiness of the standby pump starting when the main pump is in operation.

**3.4.17** One pilot operated safety relief valve per pump shall be provided.

**3.4.18** The set pressure of the safety relief valve shall be 10 bars higher than the pump discharge pressure. The full opening pressure shall preferably limited to 10 percent of the set pressure.

**3.4.19** The capacity of the safety relief valve at full opening pressure shall be at least equal to the pump capacity.

**3.4.20** The safety relief valves shall not be mounted directly on the pumps. They shall be line mounted with individual returns back to the oil reservoir.

3.5 *Filters*

3.5.1 A 100 percent capacity duplex oil filters ( main and standby ) shall be located downstream of the turn oil coolers.

3.5.2 The duplex filters shall be suitably piped with the help of two transflow three-way valves with suitable lever mechanism for quick changeover.

3.5.3 Both the filter bodies shall be connected by an equalising connection with by pass valve and orifice. The equipment shall be provided with a linking mechanism for smooth operation of the three-way valves. Suitable vents and valve drains shall be provided for easy draining of the filter bodies. Filter elements shall be easily replaced at site.

3.5.4 Oil supplied to servomotor is not filtered but the governing system oil is filtered away from the main stress, duplex filter with replaceable elements with transflow three-way transfer valve shall be provided.

3.5.5 The micron rating of duplex doubled filters in the main stream and governing line shall be 5 $\mu$, Nom and 25 $\mu$, Nom respectively.

3.5.6 The pressure drop shall be a 0·35 bar in clean condition at 40°C and 1·5 bar in dirty condition at normal flow when the changeover mechanism is put into operation. The collapsing pressure drop of the cartridge shall be a minimum of 3·5 bars. No by pass relief valves shall be permitted.

3.5.7 The minimum design pressure of the filters shall be 12 bars.

3.5.8 The filters shall be manufactured as per IS : 2825-1969.

3.5.9 A differential pressure indicator and switch shall be provided to monitor the pressure drop across the filter body in operation.

3.6 *Centrifuge* — Water and solid particles in the oil system shall be removed by an oil certifuge suitable for continuous operation.

3.6.1 The centrifuge shall be designed for a minimum throughput of 1 percent of the system normal flow, that is, capacity of lubricating, sealing and continuous governing oil.

3.6.2 A pressure switch shall be provided on the centrifuge downstream piping to stop the centrifuge in case of zero flow.

3.6.3 The clarification degree of the centrifuge shall be 5 $\mu$, Nom. Also the degree of purification shall not be more than 0·1 percent, maximum.

3.7 *Degassing Tank*

3.7.1 Whenever seal oil system is envisaged degassing facility shall be incorporated downstream of oil seals.

3.7.2 The holding capacity of the tank shall be a minimum of 7 days of seals oil discharge from the compressor drain.

3.7.3 The heater shall be either steam or electrical operated. In case of electrical watt density shall be as indicated in 3.3.5.

3.8 *Overhead Run-Down Tank*

3.8.1 Provision of an overhead run-down tank shall be made for safe-coast down of the equipment when trip occurs due to tube oil system failure.

3.8.2 The tank shall be sized for maximum coast down time of the equipment oil requirement.

3.8.3 A level switch shall be provided to give consert to start the equipment only when the level reaches the over flow connection.

3.8.4 The minimum elevation of this tank shall be 7 m above machine centre line.

3.9 *Oil Coolers*

**3.9.1** Twin coolers shall be provided in parallel arrangement with a transflow valve interposed between them on oil side. Each cooler shall be designed to dissipate total cooling load. Water shall be on the tube side. The oil side operating pressure shall always be higher than water-side operating pressure.

**3.9.2** Coolers shall be of shell and tube type with removable tube bundle and removable channel and constructed in accordance with IS : 4503-1967. Tubes shall not be smaller than 15 mm outside diameter with minimum tube wall thickness 1·0 mm. Always straight tubes shall be employed.

**3.9.3** Generally construction materials for cooler shells channels, covers, tube sheet and tubes shall be carbon steel. For specific applications other materials for tubes and tube sheets may be chosen depending on the type (quality) of cooling water flowing through the cooler.

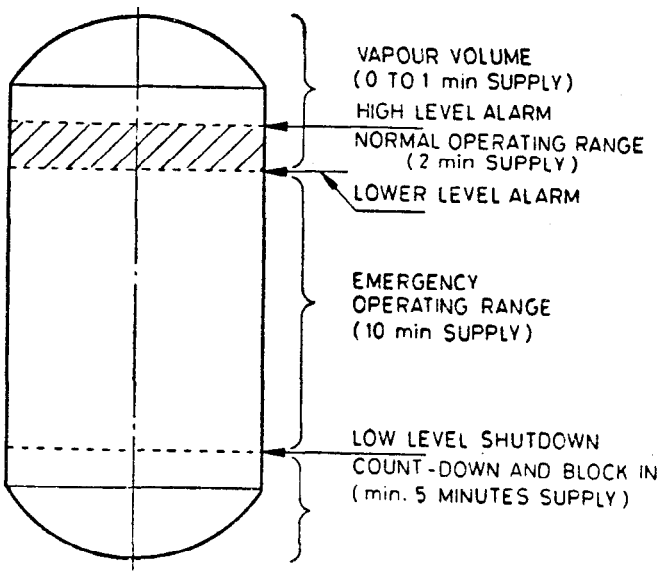
**3.9.4** Tube side water velocity at rated conditions shall be limited to 1·0 m/s to 2·4 m/s depending on the type of tube material used. The water side fouling factor shall be atleast 0·000 4 h $m^2$°C/Kcal and the maximum water-side differential pressure shall be 0·7 kg/$cm^2$.

**3.9.5** The minimum design pressure for coolers shall not be less than the maximum operating pressure of the system, not less than the shut-off head pressure for centrifugal oil pumps, nor less than the relief valve setting for positive displacement pumps. The water-side design pressure shall be suitable for the specified cooling water pressure, but not less than 6 kg/$cm^2$. When specified, coolers shall be suitable for 150°C steam heating.

**3.9.6** Suitable self-venting and draining connections shall be provided on coolers.

3.10 *Seal-Oil Overhead Tank*

**3.10.1** Seal-oil overhead tanks shall be provided when required by the designs of the seals and the seal oil control system or when specified by the purchaser as an emergency oil-rundown system. These tanks shall be machine mounted or separately mounted overhead tanks.




SEAL-OIL OVERHEAD TANK

**3.10.1.1** Seal-oil overhead tanks, shall be sized for the oil capacity above the low level alarm setting to be equal to a 2 minute flow at normal seal oil rates and shall include capacity for a 10-minute flow from low level alarm to trip plus sufficient time-on less than two minutes after trip for coast-down and block-in (5 minutes supply). Vapour volume above the high level alarm setting shall be no less than 1 minute normal oil flow.

**3.10.2** Seal oil overhead tanks shall have at least one 50-mm inspection nozzle (If any other connection is provided, this may be eliminated). A bottom outlet nozzle, if used shall extend 25 mm inside the vessel in order to retain foreign matter. A minimum 19 mm drain and flow down connection shall be provided.

3.10.3 A low oil level trip switch shall be a separate float or displacer operated switch.

3.10.4 The reference gas shall be isolated from the oil by a bladder of material suitable for the service, when specified by the purchaser.

## 4. Controls and Instrumentation

4.1 *General*

4.1.1 The oil system shall be suitable for orderly start-up, stable operation, warning of abnormal conditions, and shutdown of main equipment in the event of impending damage.

4.1.2 All control, valves, relief valves, solenoid, and diaphragm operated valves, and all other valves handling flammable or toxic fluids shall have steel bodies with stainless steel internals and trims. Controls heads for flammable fluids shall be made of steel.

4.1.3 All solenoids shall have continuous duty ratings.

4.1.4 Controls and control panels shall be completely piped, requiring only the purchaser's external piping connections.

4.1.5 Controls and control panels shall be completely wired. When more than one wiring point is required for controls or instrumentation, wiring to all items shall be provided from a terminal box. All wiring shall be installed in protective metal conduits or enclosures.

4.1.6 All controls and instruments shall be located and arranged for case of visibility by the operators as well as for accessibility for tests, adjustments, and maintenance.

4.1.7 Valved bleeders shall be required between instruments and their valves for services over 15 kgf/cm$^2$.

4.1.8 When failure or malfunction of reducing valves may cause over pressure and resultant hazard or damage to downstream equipment or components, a relief valve discharging to the reservoir shall be furnished ( *see* Fig. 2 for typical arrangement ).

4.2 *Panels*

4.2.1 At least one instrument panel for the oil system shall be provided by the manufacturer when specified. The manufacturer shall furnish and mount on or in the panels the instruments specified on the data sheets. Spaces or cut-outs, or notches, shall be supplied as specified for the purchaser's instruments. The configuration of the panels shall be as specified.

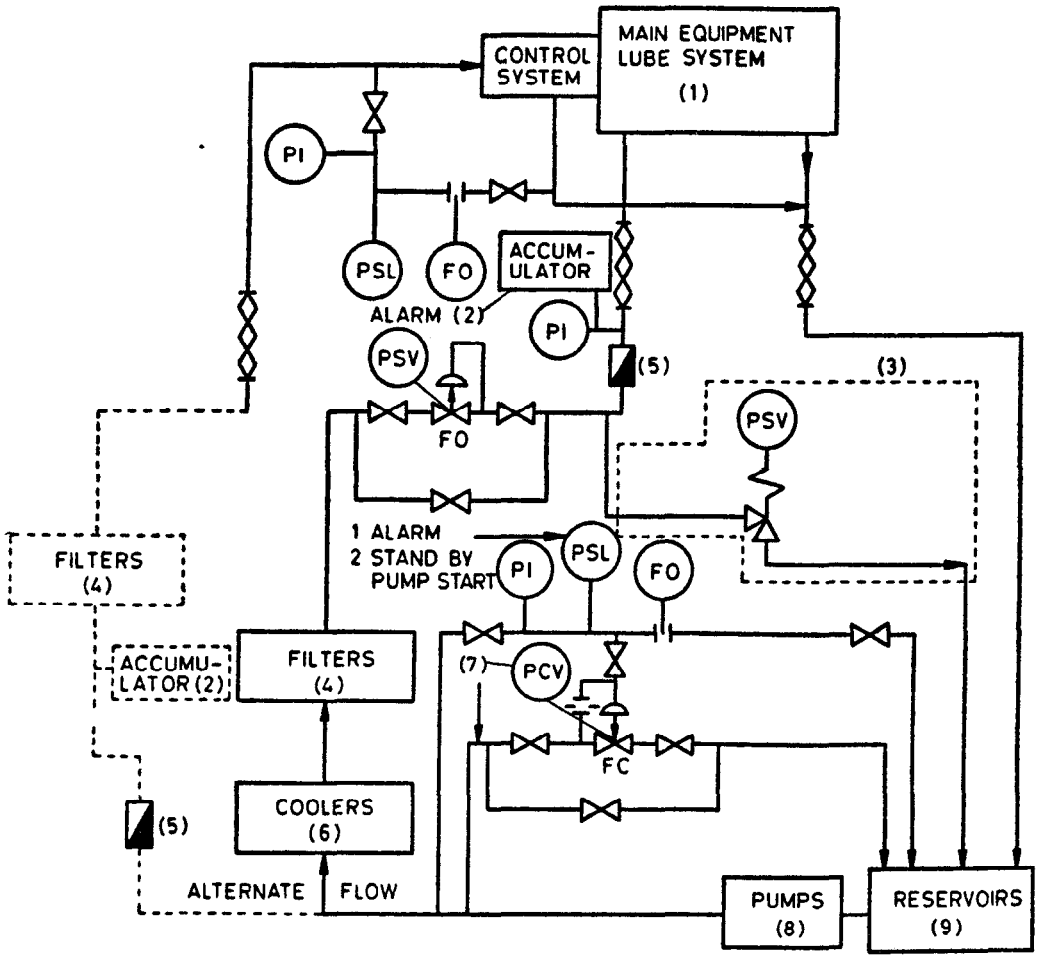
4.2.2 The types of instruments and the locations of the panels shall be specified by the purchaser.

4.2.3 After all the equipment locations have been fixed, the pressure instruments shall be piped to the terminal locations specified by the purchaser. A shutoff valve within each panel shall be provided for all lines except those for shutdown sensing devices.

4.3 *Alarms and Shutdowns*

4.3.1 The manufacturer shall furnish as a minimum, the following alarm and shutdown contacts (or bearing metal temperature detectors). The alarm setting shall precede the shut down setting.

| | *Alarm* | *Shut Down* |
|---|---|---|
| Low lubricating oil pressure auxiliary start-up | × | — |
| Low lubricating oil pressure for each level | × | × |
| Low level in reservoir for each item | × | — |
| Low seal-oil level or low seal oil differential pressure for each item | × | × |
| High overhead-tank level for each item | × | — |
| High thrust-bearing oil or metal temperature for each item (purchaser shall specify the arrangement required) | × | — |
| Standby pump running for each item (not required if the purchaser's alarms are from the motor starter) | × | — |
| High oil filter differential pressure for each item | × | — |
| High temperature after cooler | × | — |




THIS ARRANGEMENT IS VALID ONLY WHEN THE PRESSURE OF THE CONTROL OIL SUPPLY IS HIGHER THAN THE PRESSURE OF THE LUBE OIL AND THE COOLING WATER

Note 1 — Lubrication system at main equipment only

Note 2 — Direct contact-type accumulator or bladder-type accumulator when required

Note 3 — Typical arrangement for any system where a control valve failure can jeopardise or damage a low-pressure system

Note 4 — Twin oil filters

Note 5 — Omit check valve if accumulator is not used

Note 6 — Twin oil coolers

Note 7 — Omit the by pass PVC circuit if centrifugal pumps are used

Note 8 — Primary pumps

Note 9 — Oil reservoir

FIG. 2 LUBE OIL AND CONTROL OIL SYSTEM

4.3.2 A separate housing shall be furnished for each pressure-or temperature-sensing switch. 'Single-pole, double-throw' switches shall be used.

4.3.3 'Open' (de-energize) to alarm and 'close' (energize) to trip electric switches shall be furnished.

4.3.4 The manufacturer shall furnish a 'first-out' type of annunciator when an annunciator system is specified.

4.3.5 All instruments and controls other than shut-down-sensing devices shall be installed with sufficient valving to permit removing instruments and controls while the system is in operation.

4.3.6 Piping to a pressure switch for alarms shall include an orifice, a connection, a pressure gauge and bleeder valve to test the alarm. The arrangement of the shut-down-sensing device shall permit its being checked during operation where a redundent system (such as a 'two-out-of three' system) is employed. Alarm and shut-down-switch settings shall not be adjustable from outside the housing, pressure elements shall be made 18 Cr-8 Ni stainless steel.

4.4 *Thermometers* — Either 150 mm minimum size industrial thermometers or 100 mm minimum size dial bimetallic or mercury-filled thermometers shall be mounted in the oil piping of the cooler inlets and outlets and in the oil piping at the outlet of each radial and thrust bearing. Individual 18 Cr-8 Ni stainless steel wells shall be furnished in pressurized or flooded locations.

4.5 *Pressure Gauges*

4.5.1 Pressure gauges shall be furnished at the discharge of each oil pump, at each bearing and seal inlet oil header, and at the control inlet oil header.

4.5.2 Each pressure gauge shall have a 100 mm minimum size dial, 18 Cr-8 Ni stainless steel bourdon tube and movement. Each gauge shall be suitably valved to permit its removal while the system is in operation.

4.6 *Flow Indicators*

4.6.1 Flow indicators shall be furnished in the atmospheric oil-drain return line from each bearing, gear, and seal and in either the pressured inlet piping or the outlet piping of each continuously lubricated coupling.

4.6.2 Steel non-restrictive flow indicators shall be used for atmospheric drain lines. Steel restrictive flow indicators shall be used for pressure lines.

4.6.3 Each flow indicator shall be of the bull's eye type and shall be installed with its bull's eye glass preferably in a vertical plane to facilitate viewing the flow of oil through the particular line.

## 5. Inspection and Tests

5.1 *Inspection*

5.1.1 The inspector representing the purchaser shall have entry to the plants, including the subvendor plants, where work on or testing of components or sub-assemblies is being performed. It shall be the responsibility of the manufacturer to notify the subvendor of the purchaser's inspection requirements.

5.1.2 It is intended that the purchaser's inspection work be facilitated by assigning to the manufacturer the responsibility of furnishing the inspector or his representatives with all requested material certifications, with test reports, purchase specifications or bills of materials, hydrostatic and running test data, and the like necessary to verify the manufacturer compliance with the requirements of the specifications.

5.1.3 At least five days prior to scheduled shop tests, the manufacturer shall inform the purchaser of planned test date.

5.1.4 At least five days prior to the required system inspection, the manufacturer shall inform the purchaser of the planned inspection date.

5.1.5 During assembly of the system and prior to testing, each component and all piping shall be cleaned by pickling, or by an other appropriate method, to remove foreign materials, corrosion products, and mill scale.

5.1.6 The purchaser shall specify whether the purchased oil system shall be used during the shop testing of the main equipment.

5.1.7 Acceptance of shop tests shall not constitute a waiver of requirements to meet the field performance under specified operating conditions, nor does inspection in any way relieve the manufacturer of his responsibilities.

5.2 *Hydrostatic Tests*

5.2.1 Each cooler, filter, accumulator, and other pressure vessel shall be hydrostatically tested at 1½ times its design pressure. Tests shall be in accordance with code requirements where applicable.

5.2.2 Each component, subassembly, and assembled oil system shall be hydrostatically tested at 1½ times its design pressure.

5.2.3 Cooling water jackets and other components of the system handling cooling water shall be hydrostatically tested at 1½ times the design pressure of the cooling water system, in no case, however, shall this hydrostatic test pressure be less than 8 kg/cm$^2$.

5.2.4 Tests shall be maintained for durations of at least 30 min to permit complete examination of parts under pressure.

5.3 *Operational Tests*

5.3.1 The completed oil system shall be shop run to test operation, sound level, and cleanliness. The running tests shall be conducted under normal system operating conditions for at least 4 h.

5.3.2 The low-oil-pressure alarm, the standby-pump start, and the shut down switches purchased for the project, which falls in the confines of the console system, shall be used for the operational tests.

5.3.3 The operational tests shall be conducted using an oil with the same viscosity and characteristics recommended for actual field operations.

Oil temperatures ( except as noted in 5.3.6 ) and oil pressures during the operational tests shall simulate field conditions.

5.3.4 If steam is not available for the operational tests, turbine prime movers shall be tested at site for performance.

5.3.5 The operational testing of the oil system shall be conducted in the following sequence:

a) The oil system shall be thoroughly checked for leaks and all leaks shall be corrected before testing is resumed.

b) The relieving pressures shall be determined in order to establish the subsequent proper operation of each relief valve.

c) A filter-cooler changeover shall be accomplished without the systems's delivery pressure dropping to the automatic-start setting of the standby pump.

d) The control valve shall be demonstrated to have suitable capacity, response, and stability by starting, running and stopping a second pump ( main or standby ) without the relief valves lifting and without the delivery pressure dropping below 75 percent of the differential pressure between the normal operating and shut down pressures.

e) The oil-pressure control valve shall be determined capable of controlling the oil pressure by successfully operating only the main pump or the standby pump at minimum oil requirements. Minimum oil requirements shall be the sum of the normal bearing and seal-oil requirements plus the seady-state control oil requirements.

5.3.6 Conformity to the following criteria for system cleanliness shall be demonstrated.

5.3.6.1 After one hour of oil circulation at design flow rate at a temperature of 70°C ( or lower, as component design dictate ) screens shall be placed at all discharge terminations from the console or the packages and at other strategic point mutually agreed upon by the purchaser and the vendor.

5.3.6.2 Screen mesh shall be No. 100 plain weave, 127 microns diameter stainless steel or brass wire with a 0·15 mm by 0·15 mm opening. The particles shall display random distribution on the screen, piping, coolers, and valves shall be hammered frequently during the test.

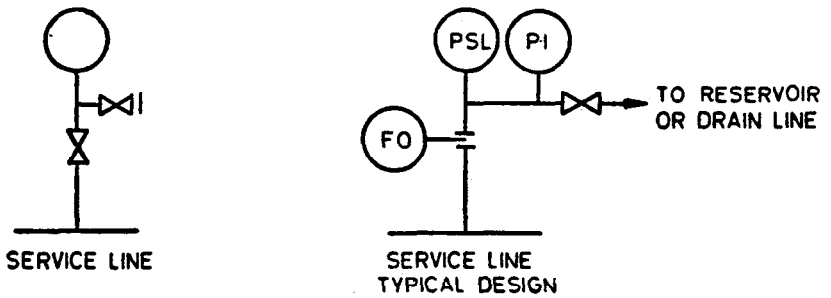
5.3.6.3 Visual inspection at approximately two to six points selected by the inspector shall be made to verify system cleanliness. The system shall be considered clean when such foreign matter as scale, rust, metal shavings, and sand are not visible to the naked eye and grittiness is not detectible to the touch.

5.3.7 If dismantling of the oil system is required to improve operation, the initial running test shall not be acceptable and final tests shall be run after corrections are made. In any event, the demonstration of cleanliness shall be conducted only after the final assembly.

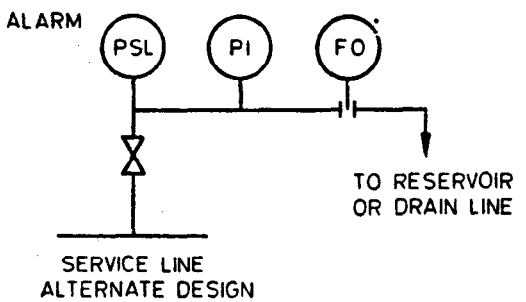
## EXPLANATORY NOTE

The schematics presented herein illustrate the general philosophy and requirements of this standard and typify commonly used systems. The systems illustrated may be modified as necessary and as mutually agreed upon by the purchaser and the manufacturer to provide a system or systems adequate for a particular application.

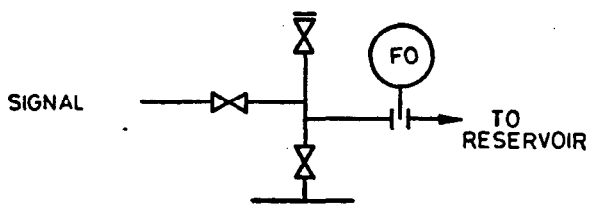
Instrument piping and valving details are not shown on most of the schematics. However, these details are illustrated in Fig. 3 and shall apply unless otherwise specified.



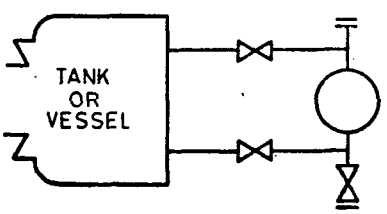

3A Pressure Gauges Switches Transformers



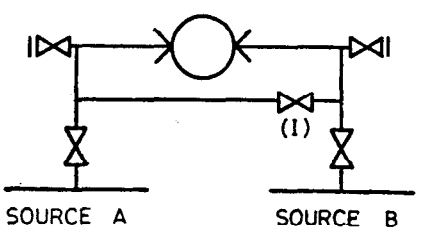

3B Combined Instrument System for Low Pressure Alarm and Pump Start Switches




3C Diaphragm Actuator




3D Externally Connected Level Instrument




3E Differential Diaphragm Actuator Indicator Switches, Transmitters

FIG. 3 INSTRUMENT PIPING DETAILS

The oil seal system is not mandatory but depends upon case to case mutually agreed between the purchaser and the manufacturer.